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GROWTH AND YIELD OF WHEAT AS AFFECTED BY COMPOST ENRICHED WITH CHEMICAL FERTILIZER, L-TRYPTOPHAN AND RHIZOBACTERIA

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Effectiveness of compost enriched with N fertilizer, L-tryptophan (L-TRP) and plant growth promoting rhizobacteria (PGPR) was tested for improving the growth and yield of wheat in a pot experiment. The compost was enriched with 25 and 50% of the recommended N fertilizer as urea, L-TRP @ 10 mg kg^{-1} compost, and PGPR culture containing $10^7 - 10^8$ colony forming units (cfu) mL^{-1} @ 100 mL kg^{-1} compost. Results revealed that the enriched compost significantly improved the growth and yield of wheat. Enriched compost along with 50% of the recommended dose of N fertilizer was more effective in improving the growth and yield (4.8 and 98.7% more than chemical N fertilizer and control respectively). These findings imply that the combined use of compost and chemical fertilizer could be more effective and economical to increase the yield of crops on sustainable basis than the chemical N fertilizer alone.
Keywords: Compost, tryptophan, nitrogen, PGPR.

INTRODUCTION

Wheat enjoys a privileged position amongst food grain crops in the world in general and particularly in Pakistan where it serves as a staple food for the majority of the population. In Pakistan, the per hectare yield is far below the inherent potential of the existing promising cultivars. Among the various determining factors, soil fertility status is of prime importance. Hence, under the prevailing circumstances, restoration and maintenance of soil fertility is a basic and critical problem. This can be accomplished by adding organic material, biologically active substances and plant growth promoting rhizobacteria, in addition to other field practices.

Now-a-days composting is becoming an increasingly important element of environmentally sound sustainable agriculture. Compost mixed with chemical fertilizer not only improves the efficiency of the chemical fertilizer but also reduces the use of chemical fertilizers (Gorttappech *et al.*, 2000).

In addition, compost along with plant growth regulators, N- fertilizer and rhizobacteria may also improve growth and yield of crops. Plant growth regulators are organic compounds that influence the physiological processes of plants at low concentration. L-tryptophan is the precursor of indole-3-acetic acid (IAA). Among indole compounds indole-3-acetic acid is the most important physiologically active auxin in plants. Soil microorganisms are considered a potential and economical source of auxin production released as secondary metabolites, which may have pronounced effects on plant growth and development (Frankenberger and Arshad, 1995; Arshad and Frankenberger, 1998). Barea *et al.* (1976) found that 80% of the bacterial isolates from the rhizosphere of various plants produced auxins in addition to other plant growth regulators (PGRs). L-tryptophan (L-TRP) is considered an efficient physiological precursor of auxins in higher plants as well as for microbial biosynthesis of auxins (Arshad and Frankenberger, 1991). Some microorganisms can produce small amounts of auxins in the absence of tryptophan, however, in its presence, the microbiota produce much greater quantities of auxins. Plant growth promoting rhizobacteria have been reported to have a potential for increasing the growth and yield of wheat (Javaid and Arshad, 1997), rice (Prayinto *et al.*, 1999) and rape seed (Noel *et al.*, 1996) in different parts of the world.

The project is designed to evaluate the effect of recycled organic waste enriched with chemical fertilizer, biologically active substances (L-TRP) and rhizobacteria for improving the growth and yield of wheat, reducing the cost of production and making it more ecologically sound.

MATERIALS AND METHODS

A pot trial was conducted to assess the potential of compost enriched with nitrogen fertilizer, L-TRP and rhizobacteria for enhancing the growth and yield of wheat (*Triticum aestivum* L.). Organic waste material containing fruit and vegetables wastes was collected from various fruit and vegetable markets of Faisalabad. This organic waste material was processed in a locally fabricated composter, consisting of drier, crusher and grinder for preparing the compost. The organic waste material collected was air-dried for 24 hours to remove the excessive moisture. Air-dried organic waste materials were graded properly to sort out all unwanted substances from the organic wastes and oven dried at 65±5°C for 24 hours before crushing. Oven-dried

material was crushed into fine particles in a crusher unit of composter. The composted product was enriched with 25 and 50% of the recommended N fertilizer in the form of urea, L-TRP @ 10 mg kg^{-1} compost and bacterial culture containing 10^7-10^8 colony forming units mL^{-1} @100 mL kg^{-1} compost. Urea fertilizer, L-TRP and bacterial culture (rhizobacteria) were mixed uniformly with the compost in a closed rotating unit.

A pot experiment was conducted in the wire house to asses the effect of enriched compost on growth and yield of wheat. A clay loam (Typic Haplocambids) soil was collected from a research field of the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad and air-dried, sieved and analyzed for various physico-chemical characters before filling into pots. The analysis of a composite soil sample revealed a pHs 7.6; ECe 1.6dSm^{-1}; cation exchange capacity (CEC) 6.6 cmol (+) kg^{-1} and organic matter 0.46%. Seeds of wheat (Watan Variety) were sown in each pot containing 14 kg soil. The recommended dose of P and K fertilizers @ 120-50 kg ha^{-1} as single super phosphate and sulphate of potash, respectively was applied in all treatments including control as basal dose by mixing them in soil before filling the pots. N fertilizer was applied in two split dosed i.e. at first irrigation and at grain formation stage. Treatments were planned as under.

T1 = Control

T2 = Non-enriched compost

T3= Enriched compost (25% recommended dose of N + L-TRP (10 mg kg^{-1}compost) + PGPR)

T4 = Recommended dose of N fertilizer (120 kg ha^{-1})

T5 = Enriched compost (50% recommended dose of N + L-TRP (10 mg kg^{-1}compost) + PGPR)

T6 = T3 + 25% recommended dose of N

T7 = T3 + 50% recommended dose of N

Growth and yield parameters i.e. plant height, number of tillers pot^{-1}, number of grains $spike^{-1}$ and straw and grain yield were recorded. N contents in straw and grain were determined according to the procedure described by Jackson (1962). The data were analyzed by using completely randomized design (Steel and Torrie, 1980) and means were compared by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS

Plant height

Results revealed that enriched and nonenriched compost alone and in combination with N as urea significantly influenced plant height. Maximum increase (19.8% greater than control) in plant height (Table 1) was observed with the application of enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) in combination with 50% dose of the recommended N fertilizer as urea. Statistically this plant height was at par where only full dose of recommend N as urea was applied.

Table I. Effect of compost enriched with nitrogen fertilizer L-TRP and plant growth promoting rhizobacteria on wheat

(Average of three replicates)

Treatments	Plant height (cm)	Number of tillers/pot	Number of spikelets/spike
Control	51.9e	8.0e	10.8f
Non enriched compost	54.2d	10.7d	12.3 e
EC (25% N+L-TRP+PGPR)	56.7c	13.7c	14.0d
Recommended dose of fertilizer	61.6a	18.0a	17.7ab
EC (50% N+L-TRP +PGPR	58.3bc	15.7b	15.7c
T_3+25%N	58.8b	16.0b	16.7bc
T_3+ 50%	62.2a	18.7a	18.61a

Mean having same letter (s) do not differ significantly at p=0.05

Number of tillers pot^{-1}

Enriched and nonenriched compost also significantly affected tillering of wheat either applied alone or in combination with N as urea fertilizer as compared to control. However, maximum number of tillers as shown in Table 1 (133.2% higher than control per pot) were recorded where enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) in combination with 50% dose of the recommended N fertilizer as urea was applied. It was followed by the full dose of recommended N fertilizer which was statistically at par with the application of enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) in combination with 50% dose of the recommended N fertilizer as urea.

Number of spikelets spike^{-1}

Like tillering, application of enriched and nonenriched compost either applied alone or in combination with N as urea fertilizer also significantly enhanced number of spikelets spike^{-1} of wheat as compared to control (Table 1). Maximum number of spikelets spike^{-1} were observed where enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) along with 50% dose of the recommended N fertilizer as urea was applied. This maximum increase in number of spikelets spike^{-1} was 72.3% higher than control. Application of the full dose of recommended N fertilizer also enhanced number of spikelets spike^{-1} (up to 63.5%) over control and other treatments.

recorded in response to the application of enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) in combination with 50% dose of the recommended N fertilizer.

Nitrogen concentration in straw

Chemical analysis (Table 2) revealed that all the treatments except nonenriched compost had a significant increasing effect on N concentration in straw over control. Maximum N concentration (31.4% higher than control) was revealed with the application of enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) in combination with 25% of the recommended dose of N fertilizer as

Table 2. Effect of compost enriched with nitrogen fertilizer L-TRP and plant growth promoting rhizobacteria on wheat

(Average of three replicates)

Treatments	Straw yield (g/pot)	Grain yield (g/pot)	Nitrogen in straw (%)	Nitrogen in grain (%)
Control	9.7f	8.2g	0.51d	1.3d
Non enriched compost	11.5e	10.7f	0.55cd	1.4cd
EC (25% N+L-TRP+PGPR)	13.5d	11.9e	0.58c	1.5c
Recommended dose of fertilizer	18.0a	15.6b	0.70a	1.8a
EC (50% N+L-TRP +PGPR	15.3c	13.0d	0.65a	1.7b
T_3+25%N	16.3b	14.3c	0.67a	1.7b
T_3 + 50%	18.9a	16.3a	0.66ab	1.8a

Mean having same letter (s) do not differ significantly at p=0.05

Straw yield

It is evident from Table 2 that the application of enriched and nonenriched compost alone and in combination with different levels of the recommended N and full dose of N as urea had significant influence on straw yield of wheat. Maximum increase (94.2% greater than control) in straw yield was observed with the application of enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) in combination with 50% dose of the recommended N fertilizer as urea. This maximum increase was statistically at par with the increase (84.9% higher than control) recorded with the application of the full dose of N as urea fertilizer.

Grain yield

The data regarding the effect of application of enriched and nonenriched compost alone and in combination with different levels of the recommended N and full dose of N as urea fertilizer depicted a significant influence on grain yield of wheat (Table 2). Maximum increase (98.8% higher than control) in grain yield was

urea. Statistically it had non significant difference with N concentration in straw where enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) alone and in combination with 50% of the recommended dose of N fertilizer as urea was applied.

Nitrogen concentration in grains

Table 2 revealed that except nonenriched compost all other treatments significantly increased N concentration in grains. Maximum increase in N concentration in grains was observed with the application of enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) in combination with 50% of the recommended dose of N fertilizer and full dose of recommended N fertilizer alone. It was followed in descending order by enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) in combination with 25% of the recommended dose of N fertilizer and enriched compost (compost + 25% of the recommended N + L-TRP + PGPR) only. Minimum increase (4.5%) in N concentration in grains was observed with the application of non enriched compost.

DISCUSSION

This study compared the effects of compost enriched with chemical nitrogen fertilizer, L-TRP and plant growth promoting rhizobacteria with the recommended dose of chemical fertilizer. In this study the enriched compost was applied as an organic fertilizer, instead of a source of organic matter, which is usually applied in tons.

Results demonstrated the efficiency of enriched compost for improving the growth and yield of wheat in a pot experiment. Enriched compost along with 50% of the recommended dose of nitrogen fertilizer significantly improved the plant height, no. of tillers/pot, no. of spikelets/spike, straw and grain yield. Our findings were in line with the results of a field experiment conducted to evaluate the influence of compost fertilizer (Zarkhez) mixed with chemical fertilizer on growth and yield of wheat and rice (Aslam *et al.*, 1998). They reported significant improvements in growth and yield. Similarly, Singh and Singh, (1999) reported the effect of compost plus nitrogen on grain yield, straw yield and total biomass of wheat, which were highest with compost plus nitrogen. It is very likely that N-losses due to volatilization, leaching or denitrificaiton might be reduced due to mixing of N-fertilizer with organic compost resulting in greater N use efficiency by wheat plants.

The results of our study revealed that application of compost enriched with L-TRP and plant growth promoting rhizobacteria significantly increased the growth and yield parameters. As L-TRP is considered an efficient physiological precurser of auxins in higher plants as well as for microbial biosynthesis of auxins from where it can be directly taken up by roots (Frankenberger and Arshad, 1995).The results of this study are in line with the study of Khalid *et al.* (1999). Their results suggested that L-TRP application @10^{-3} M with Azotobacter in a fertilized (NPK 125-100-60 kg ha^{-1} respectively) wheat field significantly improved the plant height (5.8%), straw yield (20.7%) and 1000 grain weight (6.4%) compared to control. Many other workers (Arshad and Frankenberger, 1994; Rafiq, 1995; Zahir *et al.*, 1998) also reported that application of L-TRP significantly improved the plant growth and yield of different crops.

Compost enriched with L-TRP and plant growth promoting rhizobacteria significantly increased the N contents in wheat crop both in grain and straw. These finding are supported by Khalid *et al.* (1999). They reported the combined application of Azotobacter and 10^{-3} *M* L-TRP significantly increased the N concentration in wheat grains (31.49%) in wheat compared with control. Similarly, Zahir *et al.* (1998) found that application of L-TRP @ 10^{-5} *M* significantly enhanced the yield ad NPK contents of rice compared to control.

This study clearly indicated that the organic waste material can be converted or recycled into composted form that could have positive effect on plant growth and yield by acting as source of soluble nutrients as well as by improving physical properties of soil. This composted material can be further converted into value added organic fertilizer by addition of lower doses of nitrogen as well as biological active substance and plant growth promoting rhizobacteria as the results of the study indicated that addition of 50% of recommended N level plus 10 mg L-TRP kg^{-1} compost and plant growth promoting rhizobacteria have tremendous effect on growth and yield of wheat. This implies that application of compost enriched with N, L-TRP and growth promoting rhizobacteria saved about 25% of N. So this approach may also be cost effective, can improve soil health, reduce dependence on chemical fertilizer and most likely be helpful in reducing huge piles of organic waste, thus cleaning our environment.

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